CHEMICAL OBSERVATIONS ON SUGAR.

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By EDWARD RIGBY.

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CHEMICAL OBSERVATIONS ON SUGAR.

SECTION I.

INTRODUCTORY.

SUGAR has so long been an important and extensive article of commerce, that its natural history, the mode of its culture, and the various processes, by which it is purified, and otherwise prepared, are very well known. It is, likewise, so universally made use of, for a variety of œconomical purposes, that its general properties are sufficiently understood. But until very lately, little progress has been

made in the chemical inveſtigation of its conſtituent principles; the various accounts of the chemical nature of ſugar, given by different writers, being ſufficient proofs of its true analyſis being unknown to them.

By ſome it has been deſcribed as the native ſalt of a vegetable, rendered inflammable by the mixture of a certain portion of oil.—By others it has been called an eſſential ſalt, conſiſting of an acid united with a large quantity of a very attenuated and mucilaginous earth, and with a certain quantity of ſweet and not volatile oil. And by others it has been ſaid to be a native ſoap, conſiſting of an oil rendered miſcible with water, by means of a ſaline ſubſtance.

These accounts are, obviouſly, too vague and indeterminate, not to ſay unintelligible, to be admitted as chemical definitions, and they appear, evidently, to have been derived

rived from experiments which were too imperfect to exhibit a true analyſis of this ſubſtance. For until the experiments which were made on ſugar, a very few years ago, by thoſe celebrated and indefatigable chemiſts Bergman and Scheele, and which are, certainly, the only ones which lead to a rational conjecture reſpecting its compoſition, the only proceſſes employed for this purpoſe were ſimple diſtillations, without addition, by different degrees of heat.

FROM the experiments of Scheele and Bergman, which have been alluded to, it is, however, probable, that ſugar is compoſed of a peculiar acid and phlogiſton, and the proceſs by which a ſeparation of theſe principles may be effected, is as follows.

To one part of pure refined ſugar, finely powdered, add three parts of nitrous acid; expoſe this mixture in a glaſs alembic, to a very gentle heat; a violent efferveſcence will enſue, and phlogiſticated nitrous acid

will be condenſed in the head of the alembic. When nearly one-half of the nitrous acid is diſtilled, three additional parts of the nitrous acid ſhould be mixed with the reſiduum in the alembic; a ſecond diſtillation will now take place, and when the reſiduum begins to exchange its yellow for an orange hue, the veſſel is to be removed from the heat, and expoſed in a cold air, which will very ſoon produce the ſeparation of chryſtals. The liquor in the veſſel ſhould be decanted, and the cryſtals ſhould be well waſhed in warm diſtilled water. The cryſtals may then be conſidered as the pure acid of ſugar. By adding three more parts of the nitrous acid to the remaining mixture, more chryſtals may be obtained.

The acid obtained from ſugar by the preceding operation, poſſeſſes many peculiar properties, which ſufficiently diſtinguiſh it from all other acids. It would be ſuperfluous, in this place, to enumerate theſe,

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as they may be ſeen, with its affinities for other ſubſtances, in Bergman's Diſſertations, and in his Eſſay on elective attractions.

ADMITTING the exiſtence of ſuch a principle as phlogiſton and its various affinities, according to the preſent received doctrines of chemiſtry, there can be little doubt, from the reſult of the preceding experiment, but ſugar really conſiſts, as was before obſerved, of a peculiar acid and phlogiſton; and that their ſeparation, in this proceſs, is effected by the greater affinity which the phlogiſton has to the nitrous, than to the ſaccharine acid.

IT will be the object of the ſubſequent pages to enquire whether any of the facts and phenomena which reſpect the natural production of ſugar, or any of the changes produced on this ſubſtance by other chemical operations, agree with the foregoing analyſis.

AND

And this enquiry, according to the rules of chemical inveſtigation, obviouſly divides itſelf into three parts, comprehending three different ſtates or circumſtances reſpecting ſugar.

I. Its production or compoſition by natural proceſſes.

II. Its decompoſition by art, and more eſpecially by the moſt general operation to which it is ſubjected, namely, fermentation.

III. Its revivification by the artificial reunion of its conſtituent parts. Which ſeveral ſtates I ſhall endeavor to conſider ſeparately.

SECTION

SECTION II.

Of the production or compoſition of ſugar by natural proceſſes.

SUGAR is well known to be the inſpiſſated, or cryſtallized juice of a vegetable, and it has been aſcertained by the experiments of Margraaf and others, that it forms a part of a great variety of plants, though in moſt of them it is in ſuch ſmall quantities, and ſo cloſely combined with other matter, that its ſeparation is too difficult, and the quantity obtainable, too inconſiderable, to make the proceſs worth carrying on as a manufacture: The plant from which it is obtained in the greateſt abundance, and which is at preſent alone cultivated for this production, is the ſugar cane, a native of tropical climates.

Its exiſtence in the fruits and ſeeds of many plants, is, likewiſe obvious, from their ſweet taſte, and from their juices or infuſions being capable of the fermentatory proceſs.

There can be no doubt, therefore, but ſugar is of vegetable origin, and our next enquiry muſt be, whether theſe two principles, the acid and phlogiſton, of which it ſeems to conſiſt, can be detected in a ſeparate ſtate in vegetables; or whether the experiments which have at preſent been made on vegetation, the food of plants, its aſſimilation, &c. render it probable that theſe principles are depoſited during the growth of vegetables.

Vegetables receive food in two ways, by their roots, and by their leaves; by their roots, probably, water and ſome mineral ſubſtances are abſorbed; by their leaves, it is ſuppoſed that water and the air

air of the atmoſphere are taken in: Light too, both by the direct rays of the ſun, and as it is reflected from other bodies, ſeems to furniſh ſomething ſalutary to vegetable life and increaſe.

It would, perhaps, be very difficult to aſcertain the peculiar kind of matter, which plants take in by their roots, much leſs to prove that the acid of which we are ſpeaking, is derived from the earth in which they grow. The exiſtence of an acid in vegetables is, however, not the leſs certain; the ſour taſte of the leaves of ſome, of the ſtalks of others, and of the unripe fruits of many, ſufficiently proves this; and that this acid is the ſame as that which is derived from ſugar, is highly probable, from its having been obtained by Scheele, ſome time ago, from the juice of lemons, and, more lately, from the foot ſtalks of the rhubarb plant, in which it ſeems to exiſt very abundantly.

THE nature of the principle which plants derive from the ſurrounding air, has, however, been lately more ſatisfactorily demonſtrated; and that this principle greatly contributes to the ſupport of vegetable life, and to promote the growth of plants, is evident, from the large apparatus which nature has contrived for the purpoſe of its admiſſion; an apparatus ſo admirably adapted, by the very extenſive ſurface it affords, to receive a ſubſtance of ſuch great rarity.

THE chemical reader need not be informed that this ſubſtance is phlogiſton: From the ingenious experiments of Dr. Prieſtley, and Dr. Ingenhouſz, it would ſeem, that the atmoſpheric air is received into vegetables by the medium of their leaves, that during its circulation through the plant, the phlogiſton, which was combined with the air, is depoſited in the plant, and that the air, when perfectly freed from this principle, is returned from the plant, through

through different veſſels in the leaves, into the common maſs of the atmoſphere; the leaves of plants being, therefore, analogous, as performing a ſimilar office, to the lungs of animals; with this obvious difference only, that plants return the air of the atmoſphere depurated from phlogiſton, and animals return it loaded with that principle.*

* From ſome experiments which have been made by Dr. Prieſtley, ſince the publication of Dr. Ingenhouſz's Experiments on Vegetables, and, more eſpecially, from the more recently publiſhed Experiments of Sir Benjamin Tompſon on Dephlogiſticated Air, in the firſt part of the Philoſophical Tranſactions for the year 1787; there ſeems ſome reaſon to believe, that the dephlogiſticated air, which is generated by putting the leaves and green ſtalks of vegetables into water, and expoſing them, in glaſs veſſels, to the light of the ſun, does not iſſue from the vegetables, but that it is ſeparated from the water.

This circumſtance, however it may affect the particular ſyſtem of Dr. Ingenhouſz reſpecting the reſpiration of plants (and which, I confeſs, I ſhall relinquiſh very reluctantly, it being at once ſo beautiful and ſimple) by no means diſproves the general agency of vegetables in purifying the atmoſphere, in ſome way or other; nor does it leſſen the proofs that phlogiſton forms a very material part of the food of plants.

We have in this, then, a ſufficient proof of the admiſſion of phlogiſton into vegetables by one proceſs; but it is not improbable that this principle may be alſo communicated by the ſun's rays, which, as before obſerved, are concerned in promoting vegetable life and growth, in ſome other way than by producing a warmer temperature in the atmoſphere; for, from

The original experiments of Dr. Prieſtley on this ſubject, in which air rendered ſo foul as to be unfit for the ſupport of animal life or combuſtion, was ſo far reſtored, by a ſprig of mint growing in it, as to be fit for both purpoſes, is, certainly, an incontrovertible proof of the firſt; and the peculiarly vigorous manner in which the plants, which were the ſubjects of theſe experiments, flouriſhed in the phlogiſticated air, is, equally, a proof of the latter.

Whether, therefore, the air be purified by circulating through plants, and depoſiting its phlogiſton in them, and it be afterwards expelled in a dephlogiſticated ſtate, as Dr. Ingenhouſz has ſuppoſed; or whether the phlogiſton be abſorbed by vegetables from the ſurrounding air, without the air being admitted into the circulation, the two circumſtances of the plants receiving the phlogiſton, and the air parting with it, being equally the ſame, they equally apply to the general doctrine which I have advanced, all I maintain being ſimply the admiſſion and retention of phlogiſton in all vegetables.

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ſome late experiments, there ſeems reaſon to believe that phlogiſton and the matter of light, if not one and the ſame principle, are ſo intimately combined, that wherever the latter is received, the former accompanies it. Indeed, from ſome facts and experiments, which are related in the Memoirs of the Academy of Sciences of Paris, and particularly noticed in Dr. Black's Lectures, it ſeems very probable, that the principle of inflammability is communicated to the leaves of vegetables by the ſun's light; for without expoſure to light it ſeems impoſſible to produce the green colour of vegetables; and by ſeparating this green matter by preſſure, and afterwards evaporating the water in which it is diffuſed, the green matter is obtained pure, and it appears to be the moſt oily and inflammable part of leaves.

But whether this conjecture be true or not, it is probable that the proceſs of phlogiſtication is greatly accelerated in vegetables

getables by the application of the ſun's rays, for the ſame experiments of Dr. Ingenhouſz, which I have before alluded to, prove that the excretion of dephlogiſticated air, (and which, according to his ſyſtem, obviouſly, muſt be in proportion to the ſeparation of phlogiſton from the air that has been admitted into the circulation of the plant,) is carried on only whilſt vegetables are expoſed to light, and that this proceſs is proportioned to the degree of the ſun's light: So that whether the rays of the ſun contain phlogiſton or not, whilſt their influence quickens the proceſs by which the depoſition of this principle in vegetables is effected, their agency in phlogiſtication is the ſame.

THOUGH, as before obſerved, it may be difficult to prove, that the acid of plants is communicated to them by their roots, yet as far as probability goes, it ſeems likely that it ſhould be ſo; and for the following reaſons. The difference produced by

by climate ſeems but little to affect the ſoil, its influence being principally felt by the atmoſphere, in a ſuperior temperature reſpecting heat, and a greater degree of phlogiſtication: for, with regard to ſoil, the ſame general variety of ſtrong and light, of argillaceous, mixed and ſandy, occur, perhaps, alike in all climates. Now in all climates in which vegetables can exiſt with any degree of vigor, the acid of plants ſeems to be produced: Even the fruits of warm climates will be produced in cold ones, and they will differ from thoſe which grow in warmer ones, in their having the acid principle only.

It may, poſſibly, be ſuppoſed that the atmoſphere itſelf may furniſh this acid, and the various ſuggeſtions of Dr. Prieſtley reſpecting the conſtitution of atmoſpheric air, and from which he is induced to ſuppoſe the air to be a kind of ſulphur,* would,

* Experiments and obſervations on different kinds of air, vol. i. page 261, 263, 264, 265, and vol. ii. page 55.

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would, perhaps, juſtify ſuch a conjecture: But if it be admitted that this acid is produced in vegetables nearly alike in all climates, it will very little affect my reaſoning, whether it be derived from the ſoil or the atmoſphere; for with reſpect to the production of phlogiſton, there can be no doubt but there muſt be a very great difference in climates. In hot climates, thoſe proceſſes which occaſion phlogiſton to be ſeparated from different animal and vegetable bodies, which contain it, and to be diffuſed through the atmoſphere, are, certainly, more conſtantly exiſting, and are carried on to a much greater extent, than in cold ones; nor can there be any doubt, but plants will take in phlogiſton, in the greateſt quantity, where the ſurrounding air imbibes moſt of it, and where, moreover, being more conſtantly under the influence of the ſun's direct rays, their power of aſſimilating it appears to be ſo much increaſed.

But in the 17th ſection of his laſt volume he ſeems to have relinquiſhed the idea of there being any acid whatever in the compoſition of air.

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If, therefore, the production of the acid principle in vegetables, whether derived from the earth or the air, be nearly alike, in all climates, in which vegetation can be carried on, and the production of the other principle which is neceſſary to convert this acid into a ſaccharine ſubſtance, be greateſt in warm ones, we have a very ſtriking reaſon, why the production of ſugar, and of thoſe fruits which moſt abound with ſaccharine juices, ſhould, as is the fact, be greateſt in warm countries.

It can ſcarce be neceſſary to obſerve the difference between the ſame kinds of fruit which grow in warm and cold countries, in this characteriſtic circumſtance of ſweetneſs, as a proof of the foregoing remark; for every one knows that in cold climates they are harſh and ſour, and in warm ones ſweet; but it may be remarked, that even thoſe fruits which are uſually cultivated in warm countries, if cultivated in ſtill warmer ones, ſeem likewiſe to ex-

perience a change which is conformable to theſe principles, becoming not only ripe in a ſhorter ſpace of time, as might naturally be expected, but having their juices really more ſaccharized: The orange which ſeems to acquire proper maturity in Spain, and the latitude of 35—40, when growing nearer the line, as in Jamaica and the other Weſt India Iſlands, is not only ſweeter, but the ſugar ſo much abounds, that it is often obſerved to ooze through the rind and chryſtalize on the outſide *.

It may, however, be obſerved, that phlogiſton being the general food of plants, and probably eſſential to their exiſtence, it certainly is to be found in all climates where vegetable life is ſuſtained: There can be little doubt but this muſt be true, and perhaps the great difference between warm and cold countries, reſpecting the phlogiſtication of vegetables, lies

* See Long's Hiſtory of Jamaica.

chiefly

chiefly in this; in the latter, ſuch a quantity only of this principle is obtained, as is equal to ſupport the life of plants, and to impart to them the general character of vegetables; in the former, there is probably ſuch an exceſs of phlogiſton, as to admit ſuch an extraordinary depoſit of it in plants, as will be ſufficient to neutralize, if I may ſo expreſs myſelf, their acid juices, thereby producing their ſaccharine ſtate, which may truly be conſidered as a peculiar character of vegetables.

At the ſame time, though it is very obvious that a much larger quantity of phlogiſton muſt be ſet at liberty in hot climates than in cold ones, and in ſummer than in winter, from the greater putrefaction of animal and vegetable bodies, which takes place under thoſe circumſtances, yet it may ſtill, perhaps, be objected to the preceding application of this, that the fact of a ſuperior phlogiſtication of the air, in hot climates, has not yet been aſcertained by the eudiometer, and that on the con-

trary, from the experiments of Drs. Prieſtley, Ingenhouſz, and the Abbe Fontana, the difference obſerveable by that inſtrument, between the air in hot countries and in cold ones, in ſummer and in winter, in crouded cities, and in the moſt open and expoſed ſituations in the country, is not ſufficient to account for that difference in vegetables and fruit which has been ſuggeſted.

Though I am aware that the eudiometer is not, perhaps, under all circumſtances, a ſufficient teſt of the purity of the air, as Dr. Prieſtley has himſelf obſerved, that phlogiſton may be ſo combined with it, as not to be detected by the admixture of nitrous air; yet I think it may even be admitted, that the air is not more phlogiſticated in hot climates than in cold ones, without its proving, that more phlogiſton is not evolved in thoſe countries, or that more of this principle is not abſorbed by vegetables in thoſe places: For, admitting that the proceſs of dephlogiſtication goes

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on as rapidly and extenſively by vegetation, as phlogiſtication goes on by putrefaction, it may eaſily be underſtood why the general maſs of air does not, under thoſe circumſtances, contain a more than uſual quantity of phlogiſton: the difference between climates not being, probably, in the quantity of phlogiſton retained in the atmoſphere, but in the quantity, which in a given time is received by it and paſſes through it, and this will, obviouſly, depend upon the celerity with which theſe proceſſes are carried on, and their relative proportion to each other. Indeed, were not a much larger quantity of phlogiſton ſet at liberty in warm climates than in cold ones, and vegetation could, at the ſame time, be equally ſupported, it is evident that the air muſt be much purer there than in cold ones; for as experiment ſeems to prove that dephlogiſticated air is perpetually iſſuing from the leaves and green ſtalks of vegetables, while they are expoſed to the light, or at leaſt, that vegetables, by ſome proceſs or other, effect the purification

cation of the air, it cannot be doubted, but, where the greateſt number of vegetables exiſt, where they flouriſh in conſtant ſucceſſion throughout the year, where thoſe parts of each individual vegetable, which are moſt concerned in this proceſs, are not only moſt numerous, but peculiarly large, as is moſt remarkably the caſe with the leaves of plants in tropical countries, and where, too, they are more than elſewhere expoſed to a ſtrong light, from the vertical ſituation of the ſun, and the cloudleſs ſky, which throughout the year is ſo peculiar to thoſe climates, an immenſe quantity of dephlogiſticated air muſt be produced, and doubtleſsly the whole atmoſphere, eſpecially the lower ſtrata of it, would be purer in thoſe regions than in any other on the globe, were there not conſtantly riſing from putreſcent ſubſtances, a proportionate quantity of phlogiſton to mix with it, and to ſupply freſh materials for the proceſſes of vegetation.

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I am the more diſpoſed to think this is really the caſe, and that the air is not more phlogiſticated, though more phlogiſton paſſes through it, in warm countries than in cold ones, becauſe I believe it probable, that a much greater degree of phlogiſtication than is found in temperate climates, would render it unfit for the purpoſes of animal life, as even in cold climates, where the ſources of phlogiſton are certainly feweſt, the pure, vital, dephlogiſticated air, according to the experiments of Scheele and Bergman, ſcarcely conſtitutes one-fourth part of the atmoſphere; and as the proportion of animals in different climates, is, perhaps, nearly alike, greater or ſmaller numbers, depending more upon artificial than natural cauſes, the ſame ſtandard of purity ſeems alike neceſſary in all countries.

But to return more immediately to the ſubject—The different degrees or ſtages of ripeneſs which fruits paſs through, before

fore they are perfectly mature, may, I think, be likewiſe explained on the ſame principle of a ſmaller and greater degree of phlogiſtication, compleat ripeneſs being, probably, the ſtate in which the juices of the fruit are fully ſaturated with this principle. And in this, the influence of the ſun's rays, either in immediately imparting phlogiſton, or in accelerating the proceſs by which it is ſeparated from the fluid circulating in the vegetable, is very apparent; for every one knows the difference in the ſame kinds of fruits, and which grow in the ſame climate, if planted ſo as to have different expoſures with regard to the ſun, and that even on the ſame tree, the fruit on different parts of it, will, for a ſimilar reaſon, experience the ſame difference.—And here the remark before made, that the ſources from whence the acid of plants and phlogiſton are obtained, are very different ones, obviouſly recurs, for it is evident, that this acid is produced as much in the ſhade as in the

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ſun, and, indeed, on account of the abſence of phlogiſton its preſence is, even there, moſt obvious.

ACCORDING to Dr. Ingenhouſz, plants and parts of plants, in very ſhady places, give out phlogiſticated air; we have, then, a ſtill further reaſon, conformable to the preceding general principles, why fruits, under thoſe circumſtances, ſhould be ſour; for, independent of there being leſs phlogiſton abſorbed by that part of the plant which is hidden from the ſun's light, it ſeems not even to have the power of retaining that phlogiſton, which admitted into it by ſome other part which may be expoſed to the ſun, is brought to this in the courſe of its circulation through the plant.

THE acid of fruits ſeems, alſo, to be more early depoſited than the phlogiſton, for when the fruit is firſt formed, at leaſt when it has acquired ſome degree of bulk

as well as ſhape, this acid exiſts in them; the abſorption of phlogiſton, appearing, on the other hand, to be a more ſlow proceſs, and requiring a much longer time in which to be compleated.

FRUITS, gathered while unripe, either from being prematurely pulled, or, from the climate in which they grow being incapable of further ripening them, may, in ſome degree, be improved by keeping, by being laid together in large heaps, ſo as to ſweat, &c. but even the change produced by theſe means, ſeems to be of the ſame nature with that which takes place more perfectly on the tree. Fruit is compoſed of other parts beſides the acid juice and phlogiſton of which we have been treating, it conſiſts of a kind of cellular ſubſtance, in which the juices are contained, of the cortical and other membranes. Theſe being all vegetable matter, phlogiſton, of courſe, enters into their compoſition, though it is not obvious until they undergo

undergo ſome degree of decompoſition; and this evidently takes place when any degree of putrefaction comes on. Now the changes produced by the means before alluded to are, probably, of this kind; a degree of putrefaction is induced, not indeed ſo much as materially to change the texture and quality of the body, but ſufficient, perhaps, to ſeparate ſome phlogiſton from the vegetable parts, (and that a degree of putrefaction may be induced in fruit, ſufficient to ſet at liberty ſome phlogiſton, without ſenſibly changing its form and texture, is evident, from the air which ſurrounds fruit being ſo ſoon rendered noxious), which uniting with the acid, which is in contact with it, and which has an affinity for it, renders it more ſaccharine. A ſtriking example of this may be adduced in the bruiſed parts of fruits, in which the diſunion of the vegetable matter being more compleat, putrefaction is advanced ſomewhat further, a greater quantity of phlogiſton is ſet at liberty and abſorbed by

the acid, and theſe parts become ſweeter than the reſt of the fruit; and from this circumſtance there will appear a propriety in the common phraſe applied to fruit under theſe circumſtances, that it is *rotten* ripe.

It may alſo be obſerved, that in ſome places, in order to anticipate ripeneſs, green fruit is buried for ſome time in ſtable dung when heating, in which ſituation not only is the proceſs of putrefaction, in fruit, carried on to a greater extent, from the joint circumſtances of heat and moiſture, which are well known very much to promote that proceſs, but very poſſibly ſome phlogiſton may be abſorbed by the fruit from the ſurrounding dung, which is, at that time, very largely parting with that principle. If this operation be managed with a tolerable attention to cleanlineſs, and the proceſs be not carried on too far, the fruit will acquire a not unpleaſant ſweetneſs, as I have ſeveral

times experienced in the inſtance of pears.

Some of the late autumnal fruits, which, in this climate, ſeldom attain to maturity, on account of the approach of winter, acquire a ſweetneſs from the influence of froſt; the effect of which, as in the laſt recited inſtance, is to induce a degree of putrefaction, and, probably, to ſet at liberty ſome portion of phlogiſton—Several kinds of plumbs, particularly the bullace and ſloe, are ſo well known to be mellowed by this cauſe, that they are uſually ſuffered to remain on the tree, till there has been froſty weather.

It is alſo a fact, that fruit even acquires ſweetneſs by being cooked; and this, too, is probably alſo owing to the ſame circumſtance, the evolution of phlogiſton from its vegetable parts. Heat and moiſture, which are the principal agents in cooking, evidently promote many of thoſe proceſſes by

by which the decompoſition of bodies is effected, and, perhaps, in this operation, they produce ſome ſuch change, though to a more limited extent. The texture of fruit is certainly rendered more ſoft and tender by cooking, and it may therefore be preſumed that the different parts of which it is compoſed are not only held together more looſely than before, but that ſome principles, which were before ſo cloſely combined as to be concealed, are now evolved; nor can it, on this account, be unreaſonable to ſuppoſe, that ſome phlogiſton may be ſeparated by this means, and enter into a new combination with the acid principle which it meets with in the fruit. In baking and roaſting, which, being each a kind of combuſtion, may more particularly be conſidered as phlogiſtic operations, the ſeparation of phlogiſton is ſtill more probable; and agreeably to this, it may be remarked, that when apples are roaſted near a large fire ſo as to burn the outward ſkin, the effect of phlogiſtication

giſtication is moſt apparent in the juice which lies in immediate contact with the burnt part, that being always the ſweeteſt part of a roaſted apple.

FROM ſome of the before-mentioned inſtances of fruit being ripened by other cauſes than the common proceſſes which obtain in living vegetables, and more eſpecially from the laſt recited fact, of ſweetneſs being produced in fruit by the application of heat, in cooking, &c. it may poſſibly be imagined, that the difference in climates, reſpecting the ſaccharization of fruits, which I have before conſidered as effected by a greater quantity of phlogiſton being admitted into vegetables in hot than in cold countries, may be produced, ſimply, by a ſuperior degree of heat, independent of its being the principal agent in phlogiſticating the air in thoſe climates, or of a certain temperature being requiſite for the life and vigor of plants; and the circumſtance of the

fruits

fruits of hot climates being ripened artificially in cold countries, by the application of heat in hot houſes, nearly as well as in thoſe climates in which they are indigenous, has been ſuggeſted to me as a proof of this.

I THINK it, indeed, very probable, that heat ſhould be a conſiderable agent in ripening fruit, by its immediate influence upon it; for by expanding the ſeveral parts of the fruit, they are probably rendered more capable of receiving phlogiſton, and its union with the acid may be thereby much facilitated. It appears, likewiſe, very poſſible, that the application of heat, may, in this, as in the other recited inſtances, become a means of ſaccharizing the acid principle, by ſetting at liberty ſome of the phlogiſton which entered into the conſtitution of the vegetable part of the fruit.

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This, indeed, is the more likely, because a certain limitation, with respect to heat, appears to be requisite to preserve the perfect union of the parts of living vegetable substance, an excess or deficiency of it equally disturbing the due arrangement of its constituent parts, and disposing them to disunite.

The effects of the absence of heat in producing this change of arrangement in bullace, sloes, &c. have been already noticed, as, also, that in this instance, the change was favorable to the maturation of the fruit, probably by setting at liberty some phlogiston which before that change was latently combined with the vegetable parts of the fruit, as in every change of arrangement produced in bodies containing phlogiston, some of that principle is, probably, liberated: And admitting that a a similar change is effected in the arrangement of the constituent parts of vegetables, by an excess of heat, the evolution of

phlogiſton, its union with the acid principle, and the ſaccharization of the fruit, become, equally, the probable conſequences of its application.

Perhaps, in the common proceſs of nature, fruit is maturated by theſe joint cauſes; by the immediate depoſit of phlogiſton which may have been abſorbed from the ſurrounding air by the plant, and have circulated through it, and by the evolution of phlogiſton from the vegetable part of the fruit, and which may have been effected, as before obſerved, by the immediate application of heat.

It has before been obſerved, that ſugar has been obtained from a great variety of vegetables, and though the fruits of plants are the parts in which this ſubſtance is moſt generally obvious, and are thoſe to which I have principally confined the foregoing obſervations, yet it is not limited to thoſe parts of vegetables.—The ſugar cane,

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the different kinds of aſh, which produce manna, the ſycamore maple, the birch, the cocoa tree, and many other trees, ſeem to have a ſaccharine juice circulating through them, which either naturally exuding, inſpiſſates in the form of ſugar, or being artificially drawn off in its fluid ſtate, affords a ſweet liquor capable of fermentation, and of which, in many places, wine is made.

The remark which has been before made reſpecting the greater degree of ſaccharization which fruits obtain in warm than in cold climates, may be applied to the ſeveral trees now mentioned. The ſugar-cane being, indeed, of no other uſe as a vegetable, but as it produces ſugar, is cultivated alone for that production, and is conſequently confined to the warmeſt climates: but the other trees which have been alluded to, being in moſt places cultivated for timber, they grow in very different climates, and exhibit, in a very

ſtriking manner, the difference of their production of ſugar according to the climate in which they grow: and as the ſugar, in this inſtance, is leſs combined with vegetable matter than the ſugar of fruits, as it exiſts in parts of plants which differ very materially from fruit in their natural ſtructure, and, as in many of theſe inſtances, it is contained in trees which are not ſubjected to the ſame annual decay which fruits undergo, the production of the ſugar in them is leſs likely to be effected by any of thoſe cauſes of the decompoſition of their vegetable parts, which have before been enumerated, as probably aiding the maturation of fruit, and therefore, being, perhaps, leſs likely to be affected, in this way, by the immediate influence of heat, the difference of their ſaccharization according to the climate in which they grow, may with ſtill more propriety be referred to the differences which thoſe climates exhibit reſpecting the production of phlogiſton.

The ſycamore, or ſugar-maple, produces very little ſaccharine matter in the northern countries of Europe, but in the warmer parts of America, it is ſo abundant in this tree, that the inhabitants collect it, and prepare from it a ſugar which anſwers the purpoſe of the ſugar obtained from the cane. The ſame may be remarked of the birch-tree when planted in a warm climate, for it has been obſerved by botaniſts, that the exudation of ſugar from this tree, under theſe circumſtances, is ſo great, as very ſoon to exhauſt its vigor. The larch, too, which in cold countries is ſcarce ever obſerved to give out a ſaccharine fluid, has it in conſiderable quantity when growing nearer the ſun; in the ſouth of France a kind of manna is obtained from this tree, of a ſimilar kind, but not of equal purity to that which is produced from the manna-aſh.—And with regard to the manna-aſh, this general difference of climate, as reſpecting its ſaccharine produce, is not only obſervable, in common with

with the other trees before-mentioned, but another circumſtance may be remarked concerning it, which ſeems very ſtrikingly to agree with the preceding theory, and which is, that this tree produces the largeſt quantities of manna in the neighbourhood of volcanos, in which ſituation the ſupply of phlogiſton muſt evidently be particularly abundant.—Calabria, in Sicily, and the neighbourhood of Naples, in Italy, are the places in which the manna-aſh is cultivated to the greateſt advantage, producing the manna there more abundantly, and of a more purely ſaccharine quality than even in the warmer countries of the eaſt.

The effect which vicinity to volcanos has on vegetation, has been well obſerved by Sir William Hamilton, Mr. Brydone, and other philoſophic travellers; indeed, all accounts of theſe countries agree reſpecting the extraordinary vegetation which takes place in thoſe ſituations, and which

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it ſeems not unreaſonable to attribute to the plentiful ſupply of phlogiſton which ſuch ſituations afford.

In ſome other parts of plants, more eſpecially in farinaceous ſeeds, ſugar ſeems, moreover, to exiſt in a latent ſtate, at leaſt it is not obvious until ſome peculiar change in the arrangement of their component parts has been effected. The ſaccharine principle, in barley, may be adduced as an inſtance of this ſort, and its evolution, by the operation of malting, may, I think, be ſufficiently explained on the foregoing principles.

Vegetation is one of the ſeveral proceſſes by which a new arrangement of the component parts of certain bodies is effected, and to produce this, it ſeems probable, that ſome parts muſt be ſet at liberty and rendered obvious, which were before ſo cloſely combined as to be concealed from the ſenſes.

Barley

BARLEY, in its natural ſtate, diſcovers no mark either of acidity or ſweetneſs, and like other vegetable matter gives no proof even of its poſſeſſing phlogiſton until its decompoſition take place by putrefaction, combuſtion, &c.—The exiſtence of an acid and phlogiſton are both, however, ſufficiently obvious in ſome of the changes of arrangement wrought on this grain. Barley-meal, which is merely pulverized barley, if moiſtened and expoſed to the air under a certain temperature, and for a given time, will become very ſour; this mode of obtaining a very powerful acid both from barley and rye, having been long adopted by tanners, who apply it for ſome neceſſary purpoſe in their operations on leather.—And it is needleſs to obſerve, that barley grain, as well as all other vegetable matter, is inflammable, and conſequently, according to the preſent doctrines of chemiſtry, it contains phlogiſton.

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THESE two principles, therefore, the vegetable acid and phlogiſton, being component parts of this grain, it is not unreaſonable to ſuppoſe that ſome of each ſhould be ſet at liberty in the vegetative proceſs of malting, and that, uniting with each other in the moment of their individual ſeparation from the other ingredients which compoſe the barley, they ſhould, in that union, aſſume the ſame new ſaccharine character, which their combination, in the ſeveral before-recited inſtances, appears to have produced.

THERE are ſome farinaceous roots, alſo, which, in their common ſtate, exhibit no marks of ſweetneſs, but which diſcover it by undergoing ſome change of the arrangement of their conſtituent parts, by putrefaction or vegetation; and by which, probably, as in the laſt recited inſtance, the ſaccharine principles are evolved. Potatoes, which have been frozen, or which have began to ſprout, always acquire a

ſweet taſte. And if this ſweet taſte were not a ſufficient teſt of the preſence of ſugar, there are other proofs of the principles of ſugar being contained in potatoes; for it has been lately found that inflammable ſpirit may be obtained from them, and that very abundantly: and it will, I believe, be found, that inflammable ſpirit is produced by an operation, the only true ſubject of which is ſaccharine matter, namely, fermentation.

Nor is this union of phlogiſton and this peculiar acid, and the conſequent production of ſugar, entirely confined to vegetable proceſſes; in ſome inſtances, though the acid be of vegetable origin, the phlogiſton appears to be derived from animals.

The natural hiſtory of the puceron, or vine-fretter, affords a very ſtriking inſtance of the production of a ſaccharine juice, and from the very ſingular manner in which

which it is obtained, it ſeems very probable that the proceſs is a phlogiſtic one.

It appears, from obſervations made by an ingenious and attentive French naturaliſt, the Abbè Boiſſier de Sauvages, that ſwarms of theſe little animals fix themſelves, in the ſummer time, on the young and ſucculent branches of various trees, and that their food conſiſts of the juice which they extract from the tree by piercing the bark of theſe young and ſlender branches.—This juice, in the green parts of moſt vegetables, is acidulous, and is peculiarly ſo in the green ſtalks of the tree on which theſe inſects moſt abound, and from which they take their name, namely, the vine. At a certain period, after receiving this acid as food, they part with it as excrementitious, in the form of a gelatinous amber-coloured liquor, which is exquiſitely ſweet. It falls upon the neighbouring leaves, or upon ſtones or other bodies, which may be near or under the animals, at the time of

its being ejected, and produces one ſpecies of what is commonly called honey dew, and which is eagerly ſought after by bees, ants, &c.

THE change which this vegetable acid juice undergoes, by paſſing the ſtomach and inteſtines of theſe animals, and which, to uſe the words of the Abbè Boiſſier, "though at firſt hard and ſour, "becomes in the bowels of this inſect, "equal to the honey obtained from the "flowers and leaves of vegetables," may, I think, with great probability, be attributed to the phlogiſton which it receives under theſe circumſtances; for minute as theſe inſects are, if we admit that they belong to the general claſs of animals, and are conſtituted like them, there can be little doubt of the exiſtence of phlogiſton in their inteſtines, which are well known, in all other animals to furniſh this principle very largely; and from this circumſtance, we may ſurely conſider this as another inſtance of the

production

production of ſugar from a combination of the vegetable acid and phlogiſton.

Even the ſweetneſs of honey is probably increaſed, if not in many caſes totally produced by phlogiſtication in the body of the bee: for it appears from Reaumur's Hiſtory of this extraordinary inſect, that the vegetable juice which they collect from flowers, remains ſome time in their bodies before it is depoſited in the cells of the hive, in which ſituation, it is probable, that it undergoes a ſimilar change to that of the acid juice which paſſes through the vine fretter.—There can be no doubt of the difference between the taſte of honey and of that fluid which is generated in the nectaria of moſt flowers, and particularly in the circumſtance of ſweetneſs; for though in the nectaria of ſome flowers this fluid is found very ſaccharine, yet bees collect juice from various flowers, in which no ſweet liquor can be detected,

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and which, therefore, ſeems to require ſome addition of phlogiſton before it can aſſume ſo ſaccharine a ſtate as that of honey.

It is probable that there are other inſects which alſo produce a ſaccharine ſubſtance in a ſimilar manner.—In the Memoirs of the Royal Academy of Sciences at Stockholm, for the year 1785, there is a paper, by M. Bjerkauder, which gives an account of a kind of ſugar or honey found in ſome parts of the red fir, which is derived from flies.

These are the principal facts which I ſhall notice reſpecting the natural production or compoſition of ſugar: The naturaliſt who is more acquainted with plants and animals, and the practical chemiſt, who is better able to analyze the various bodies which may contain this ſubſtance, might undoubtedly much extend them. But even theſe appear to me ſufficient for the purpoſe for which I have adduced them

them, namely, to ſhew the probability of all native ſaccharine ſubſtances being de-derived from the union of the two principles, which I have ſo often before mentioned, namely, phlogiſton and a peculiar acid.

SECTION

SECTION III.

On the decompoſition of ſugar by art, and more eſpecially by the moſt general operation to which it is ſubjected, namely, fermentation.

THE decompoſition of ſugar ſeems to be effected by three different proceſſes, by combuſtion, by the application of the nitrous acid, and by fermentation.

THE operation of combuſtion upon ſugar is, probably, the ſame as on all other inflammable ſubſtances, the conſtituent parts of which are unable to reſiſt the effects of a certain degree of heat, and are not only ſeparated from each other, but are volatilized and diſſipated in the ſurrounding air, and thereby totally loſt to the ſenſes. Not being able, therefore,

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to trace the principles of ſugar as they are diſunited by this proceſs, the conſideration of it would, in no reſpect, tend to elucidate the preſent enquiry, and I ſhall only obſerve, that ſugar burns at a moderate degree of heat, and, therefore, if the preſent opinions reſpecting inflammable ſubſtances be juſt, this proceſs proves that it certainly contains a conſiderable portion of phlogiſton.

By the application of the nitrous acid, I allude to the proceſs related in the firſt ſection, and which, as having been before mentioned, it would be ſuperfluous to repeat in this place.

But fermentation is the proceſs to which ſugar is moſt generally ſubjected, the ſeveral reſults of this operation being of the moſt extenſive œconomical uſe, and forming very important articles of manufacture and commerce; for it is well known, that

by fermentation, wine, vinegar, and ardent ſpirits are produced.

As in this proceſs the decompoſition of ſugar is effected much more ſlowly than in either of the preceding ones, and as its conſtituent parts ſeem to be much leſs diſſipated than in thoſe proceſſes, we may expect to be more able, in this, to trace the ſeveral changes effected on this ſubſtance; and if the preceding general doctrine be true, we may alſo expect that it will aſſiſt us in explaining the principles of fermentation, and in accounting for the ſeveral changes which are produced on the ſolutions of ſugar by that very ſingular proceſs, and which, I believe, have been hitherto very imperfectly explained.

I conſider ſugar, properly ſpeaking, as the only true ſubject of the fermentatory change, for though, in common language, it has been ſaid, that vegetables, in general,

ral, are the ſubjects of fermentation, and though many vegetable ſubſtances are in different acts expoſed to this proceſs, yet I believe it will be admitted, that it is from the ſaccharine parts only of theſe ſubſtances, that the vinous and acetous reſults of fermentation are derived.

THE baſis, therefore, of all liquors, capable of the vinous and acetous fermentation, is ſugar, either naturally diſſolved in a watery menſtruum, as in the juice of the grape, and other ſaccharine fruits, or in artificial ſolutions of it in water; and as the great change produced by fermentation is the diſpoſing the body, which is the ſubject of it, to aſſume a new arrangement of its conſtituent parts, it may be preſumed that the firſt effect of this proceſs on ſugar, is the ſeparation of its parts as primarily combined.

THE firſt object of many chemical operations is to enlarge the ſurface of the body

to be acted upon, and by dividing its integrant parts to diminish their attraction of cohesion; in hard bodies this is done by pulverization, and in soluble bodies by diffusion in a menstruum.

For the process of fermentation which is to effect a separation of the component parts of sugar, its solution in water seems first necessary for the above reason; for it is evident that sugar in its concrete state, even though its particles be ever so minutely divided by pulverization, is incapable of undergoing the fermentatory change.

Nor indeed is bare solution sufficient, it must be a dilute solution, for if such a quantity of sugar be mixed with the water as to give the compound the consistence of syrup, it will still resist fermentation.

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And further, even this ſolution requires to be rendered ſtill more rare, before the true proceſs of fermentation can take place; and the matter of heat, whoſe tendency to ſeparate the particles of bodies, in various proceſſes, is ſo well known and eſtabliſhed, ſeems to be the agent which effects this; for next to ſolution in a menſtruum, a certain temperature reſpecting heat, appears requiſite, before a true fermentation can be excited.

When reduced by the joint powers of a diſſolving menſtruum and an expanding heat, to a ſtate of extreme rarity, the ſurface of the ſugar is ſo much extended, and the coheſion between its component parts is ſo much weakened, that they become liable to be acted upon by the ſurrounding medium, according to the general laws of chemical affinity, and ſuch a change in the arrangement of the ſeveral parts of the compound takes place as may be explained to ariſe from the operation

tion of a ſuperior attraction: fermentation ſeeming, therefore, to effect the decompoſition of ſugar upon the ſame principle as the decompoſition of other bodies is effected by combuſtion, and of others by vegetation, &c. as may be inſtanced in the burning of all inflammable bodies, in the calcination of metals, in the malting of barley, &c.

INDEED the analogy between fermentation and combuſtion is very ſtriking, as they both ſeem to produce a change of arrangement in the component particles of a body, in conſequence of the body being brought into circumſtances of ſuch great rarity, or ſuch weak coheſion that a ſuperior affinity totally diſunites them: thus a piece of coal, or any inflammable or metalic body, among other principles, conſiſts of the matter of heat and phlogiſton, but both theſe, during combination, are ſo cloſely united to the other parts of the coal as not to be obvious to our ſenſes,

ſes, and are not, under the common circumſtances in which it is found, diſpoſed to ſeparate: but by the application of a certain degree of heat, acting in a ſenſible manner, the coheſion of the parts of the coal becomes ſo much leſſened, that at this time the affinity of the particles for each other becomes leſs than their affinity for the ſurrounding medium, namely the atmoſpheric air, and they conſequently, according to the great law of chemical attraction, ſeparate from each other, and unite with the ſurrounding air.

In the ſame manner, it may be preſumed, the component parts of ſugar, which appear to be principally phlogiſton and a peculiar acid, when this ſubſtance is reduced to a certain degree of tenuity, by the means before mentioned, have the ſame tendency to ſeparate from each other, and unite with the ſurrounding medium, which, in this inſtance, is water, and for which their attraction, under theſe

theſe circumſtances, is ſuperior to the attraction between each other.

ADMITTING, therefore, that fermentation is, as before ſuggeſted, a proceſs by which the decompoſition of ſugar is effected, and that it is induced by the means and on the principles which have been mentioned, we muſt next advert to the effects produced by this operation on the fluid in which it is carried on, and which, if the preceding theory be a juſt one, we may expect will afford a further confirmation of it, as well as be another proof that the component parts of ſugar are really ſuch as have been all along ſuppoſed.

WHEN the proceſs of fermentation has continued for ſome time, it may be ſuppoſed that the two ingredients, of which we imagine ſugar to be principally compoſed, diſunite from each other, mixing with the general menſtruum as diſtinct bodies, and the peculiar properties belonging to each individually,

individually, being now no longer latent, communicate a new ſtate and character to the liquor in which they are diffuſed, for inſtead of its being a ſaccharine liquor, we ſhould now expect it to be a phlogiſticated acid liquor; and this is obvious in the firſt change the liquor undergoes, for inſtead of its being ſweet, as before, it immediately acquires an auſtere taſte, which may be attributed to the acid, and at the ſame time exhibits the preſence of a ſpirituous and inflammable principle, and which may be attributed to the phlogiſton; both which evidently belong to the vinous character; ſo that the union of theſe three ingredients, namely, water, phlogiſton, and the acid of ſugar, appears, therefore, to conſtitute wine.

But though when theſe ingredients have ſeparated from each other and united with the water, the operation of fermentation may be conſidered as compleated, as far as it relates to the decompoſition of ſugar,

it is not perfected, if conſidered with reſpect to the new compound which is the reſult of the union of theſe ingredients with water, or, in other words, with reſpect to the production of wine; for there are ſome other ſubſtances, beſides the acid and phlogiſton, which are either combined with the ſugar, as component parts of it, or which are adventitiouſly united to it, in the vegetable from which the ſugar is derived, which as they do not contribute to the vinous character, muſt be ſeparated, and theſe are known under the general name of fæcula or lee, and which are uſually precipitated merely by the liquor remaining for a conſiderable length of time at reſt.—The acid of ſugar itſelf ſeems, alſo, too abundant, at firſt, for the true character of wine, and though ſoluble in water in a certain temperature, it ſeems not ſo perfectly ſo in the temperature under which wine is uſually kept, as that a quantity, which is more than neceſſary for wine, can be held in permanent ſolution; and, therefore,

therefore, when the wine has been for ſome time kept at reſt in caſks, the ſuperabundant acid ſeparates, and chryſtalizes on the ſides of the veſſel, and to this is given the name of tartar.

This acid, though thus evidently derived from ſugar, ſeems, however, to be materially different to the acid of ſugar; but this will not ſeem extraordinary, as probably, it has formed a combination with ſome other vegetable matter, which ſeparates at the ſame time from the general maſs. That the fixed vegetable alkali is united with it, though not to a degree of ſaturation, is well known by common chemical experiments, as it can be eaſily ſeparated from it; and there can be no difficulty in tracing this, the lees of wine being evidently alkaline. The other materials with which the acid unites, may probably have ſuch an affinity for it as not to be eaſily ſeparated by any of the common proceſſes of chemiſtry. But ſup-

poſing this even to be impracticable, there would ſtill remain no doubt of the origin of the acid of tartar, as it is immediately derived from ſugar. The induſtry of the celebrated Scheele has, however, removed all poſſible doubt on this ſubject, as he has actually produced the true acid of ſugar from tartar; and from ſome other experiments of Scheele's and Dr. Crell's, the ſimilarity of the acid of tartar to the acid of ſugar is not only fully aſcertained, but it ſeems probable that the acids of tartar, ſugar and vinegar, which are all produced from ſugar by different proceſſes, are all modifications of the ſame acid, as it is united to more or leſs phlogiſton, and that the acid of tartar has the greateſt quantity combined with it, the acid of ſugar has ſomewhat leſs, and the acetous acid has the ſmalleſt quantity*.

THE

* See Scheele's Eſſays—Engliſh Tranſlation, page 388. See, alſo, Experiments and Obſervations on the Converſion of the acids of Sugar and of Tartar into Vinegar, by by M. Hermſtadt, in the Journal de Phyſique for September, 1787, from which it appears probable, that the acid of

THE vinous fermentation being thus perfected, by the ſeparation of the ſuper-abundant acid and the other adventitious vegetable matter, the auſtere taſte which it before had is now much leſſened, and the wine is ſofter and more grateful to the palate, but retaining the phlogiſton it is ſtill inflammable, and has equally the power of producing intoxication, which it may reaſonably be ſuppoſed is derived from that principle.

THAT the phlogiſton is ſtill in a ſtate of combination with the liquor, is not only probable from the preceding circumſtances, but its actual ſeparation may be effected by art; for, by diſtillation, ardent ſpirit is obtained from wine; which has always been conſidered as phlogiſton united to ſo much water as will fix it, thereby preventing its aſſuming that aerial form

of ſugar, the acid of tartar, and the acetous acid, may each, by different proceſſes, be obtained from various vegetable acid juices, as the acid of tamarinds, of lemons, the juice of plumbs, apples, pears, gooſeberries, ſorrel, berberis, &c.

which

which, with a ſmaller quantity of water, or with the ſurrounding air, it would probably put on.

THE acetous ſtate which is brought on by fermentation in watery ſolutions of ſugar, is evidently that ſtate of it, in which, after the diſunion of the two principles of ſugar, the acid remains principally combined with the menſtruum, in conſequence of the eſcape of phlogiſton.—This is effected by what is called the acetous fermentation, and which is in reality the ſame kind of proceſs which produced the vinous ſtate of the liquor, only extended ſomewhat further: and I think it may be thus explained.

IF, after the ſeparation of the component parts of ſugar, and their combination with the ſurrounding water, have been effected by what is properly called the vinous fermentation, a degree of heat be communicated to the new compound, more than was requiſite for the before-

mentioned

mentioned purpoſes, it will produce, upon the common principle of heat, a further rarefaction of the liquor, and the coheſion between its ſeveral parts will be proportionately diminiſhed; and ſhould either of the principles, which by the previous operation became united with the water, become by this means ſo looſely attached to it, as on the approach of another fluid to be ſenſible of a ſuperior attraction, it will, as in the former proceſs, quit that body to which it is attached by an inferior affinity, and unite with that to which it is attracted by a ſuperior affinity. It is probable that the phlogiſton, as the rareſt and moſt volatile of the ingredients which enter into the compoſition of wine, will be moſt eaſily looſened from the medium in which it is diffuſed, by the application of heat, and if in this ſtate of imperfect coheſion, the ſurface of the liquor be in contact with the atmoſpheric air, which has a well known and powerful affinity for phlogiſton, it is highly probably that it ſhould be ſo far attracted by it, as to quit the liquor, and uniting

uniting with the air, be diſſipated; and it is evident that if this take place to ſuch a degree as to dephlogiſticate the liquor, it will remain compoſed only of the water and the acid, and conſequently be ſour.

The two circumſtances of a ſuperior temperature, with regard to heat, and the expoſure to the ſurrounding air, being indiſpenſably requiſite to induce the acetous fermentation, certainly very much ſtrengthen the above conjecture.—And it is rendered ſtill more probable by another fact, in which the ſeparation and removal of phlogiſton from vinous liquors render them ſour.

After the ſeparation of phlogiſton from wine has been effected by diſtillation, and which, as before noticed, takes place when ardent ſpirit is obtained, a ſour feculent liquor remains behind. Indeed this and the former operation by which a ſour reſiduum is produced, are very ſimilar,

both

both depending upon the ſame circumſtance, the removal of phlogiſton.

When vinegar is produced by the acetous fermentation, juſt ſuch a degree of heat is, probably, neceſſary as will volatilize the lighteſt part only of the compound, and which, as before obſerved, is moſt probably the phlogiſton, this heat being found, by experiment, to be from 70 to 80 of Fahrenheit: and when, therefore, it eſcapes in this rare and light ſtate, it may eaſily be imagined that it will unite with the ſurrounding air, and be ſoon loſt to the ſenſes in the general maſs of the atmoſphere. When wine is ſubjected to the proceſs of diſtillation a much greater heat is applied, and it being more than ſufficient to ſeparate the phlogiſton, a portion of water, with perhaps ſome other principle, is raiſed at the ſame time, which uniting with the phlogiſton, the compound is rendered more obvious to our ſenſes, than the phlogiſton in its ſeparate and more rare

ſtate, or when united only to air, can be ſuppoſed to be, and we are, conſequently, able to collect it thus combined, in proper receivers.

VINEGAR is, moreover, produced from ſugar by another proceſs of dephlogiſtication, namely, by being placed in circumſtances in which manganeſe can act upon it, by which it is ſoon deprived of its phlogiſton; for, during the proceſs, a ſharp vapor ariſes, which, when collected in a receiver, appears to be true vinegar*. The only difference between this operation and the fermentative proceſs by which vinegar is produced, being that in the latter the phlogiſton is volatilized and diſſipated, and the acid is left behind united with the water, and in this the acid is raiſed in the form of vapor, and the phlogiſton remains behind, being abſorbed and fixed by the manganeſe.

* See Scheele's Eſſays—Eſſay v. on Manganeſe—Section xxviii.

I wiſh

I wiſh I could have added, in confirmation of the preceding theory of acetous fermentation, that experiment had proved that the air, which is in contact with the ſurface of the wine, when the proceſs is going on, is phlogiſticated, which it certainly muſt, if the foregoing conjecture, reſpecting the eſcape of phlogiſton during that operation, be true.—I have never, myſelf, had an opportunity of obſerving this operation upon ſo large a ſcale as would probably be requiſite to decide this circumſtance, and I believe the air which riſes from the ſurface of liquors undergoing the acetous fermentation has not yet been properly ſubjected to experiment. It would, however, be no difficult matter to aſcertain this in places where wine and vinegar are articles of manufacture, more eſpecially as the methods of diſcriminating between phlogiſticated and other airs, and even of aſcertaining the degree of phlogiſtication which the air may

have ſuffered, is at this time ſo well underſtood.

It muſt, at the ſame time, be admitted, that the general accounts of this proceſs, which are found in books of chemiſtry, very much favour this opinion; as they all agree in theſe two circumſtances, that heat and the free acceſs of the external air are neceſſary to the acetous fermentation, and, moreover, that there really does ariſe from liquors, in this ſtage of fermentation, ſome principle which imparts a noxious quality to the ſurrounding air. It is, indeed, obſerved by Neumann, Macquer and Baumè, that the air which ariſes, during this operation, is not ſo noxious as that which is produced by the vinous fermentation. But at the time when theſe chemiſts wrote, the nature of this air, and of fixed air, or aerial acid being totally unknown, it is not to be wondered at, that they could diſtinguiſh them in no other way than as the one appeared more noxious than the other:

other: and though phlogiſticated air be as incapable of ſuſtaining animal life and combuſtion as fixed air is, yet a ſufficient reaſon may be ſuggeſted why the latter muſt appear much more noxious than the former, if an experiment be made on both reſpecting their power of extinguiſhing life and combuſtion, as they are found on the ſurfaces of liquors undergoing the reſpective fermentations. For fixed air being heavier than atmoſpheric air, it muſt neceſſarily remain, as an increaſing ſtratum on the liquor, and conſequently be in as denſe a ſtate as it is capable of aſſuming: whereas the former, or phlogiſticated air, having leſs ſpecific gravity than the air of the atmoſphere, cannot be ſtationary as fixed air is, but muſt conſtantly be quitting the ſurface of the wine, where it was generated, by its tendency upwards; ſo that unleſs it were detained on the ſurface by ſome mechanical contrivance, it could never be found but in ſo rare a ſtate, that if ſubjected to the experiments before alluded

luded to, reſpecting the extinction of animal life and combuſtion, it muſt, from compariſon, appear much leſs noxious than fixed air.—There is, however, an experiment of Dr. Crell's, related in Scheele's Eſſays, by which vinegar is produced from the acid of tartar and ſpirit of wine, (and which, when united, muſt evidently be ſimilar to wine, at leaſt muſt contain the ſame principles) in which the incumbent air became phlogiſticated. It is thus related—"If acid of tartar and ſpirit of wine be digeſted together for ſeveral months, the whole is converted into vinegar, and the air in the veſſel becomes partly fixed and partly phlogiſticated*."

From what has been ſaid, I think it appears pretty evident, that wine is formed of phlogiſton, a peculiar acid and water that vinegar is formed of this acid and water without the phlogiſton, and that in-

* See Scheele's Eſſays, page 387.

flammable

flammable ſpirit is produced by the union of the phlogiſton with water without the acid; that the phlogiſton and this peculiar acid are obtainable from ſugar, being evidently produced by the decompoſition of this ſubſtance, and that the proceſs which diſpoſes ſugar to give out theſe principles to water is fermentation.

The true vinous character and peculiar qualities of wine alſo depend upon the perfection of the decompoſition of ſugar, and upon the proper and proportionate combination of theſe principles with water: a variation in this reſpect, joined to the mixture of bodies which are adventitious to ſugar, but produced with it in the vegetable body from which it is derived, conſtituting the difference between wines. Thus the ſaccharine principle in barley being cloſely united to the farinaceous part of the ſame grain, it is, perhaps, impracticable to make a perfect ſolution of the one in water, without imparting to it ſuch a portion

a portion of the other, as will affect the proceſs of fermentation, and give a peculiar character to the wine ſo produced. Hence the difference between ale, the vinous liquor produced from the ſaccharine part of barley, and wine produced from the juice of the grape.

In wine, made from the juice of the grape, the ſeparation of the phlogiſton from the acid ſeems to be moſt perfectly effected, and the redundant acid being more completely done away, the wine thus produced is certainly the moſt perfect example of a vinous liquor. There is, however, an obvious difference in wines made from different grapes, and one of them is the unimportant one of colour, which ſeems to bear no relation to the act of fermentation, it being, probably, produced extractively from the ſkin of the grape, merely on the common principle of maceration.

It may, perhaps, be remarked, that I have not mentioned fixed air as one of the conſtituent parts of ſugar, though it is evidently produced during the vinous fermentation of all ſaccharine liquors, and it has generally been conſidered as derived from the ſugar. I have not done this, becauſe I believe it would be difficult to prove that it previouſly exiſted as an ingredient in the ſugar; more eſpecially as at this time chemiſts are not quite ſatisfied about the nature of this principle, and it is even contended, that it is compoſed of phlogiſton and pure air. Should this be the caſe, it may evidently be produced by ſome redundant phlogiſton which does not combine with the water, when the decompoſition of ſugar firſt takes place.

It may be right ſtill further to obſerve, before I conclude the ſubject of fermentation, that in ſtrict chemical truth, all the liquors derived from the decompoſition of ſugar in water, by the ſeveral proceſſes of

the vinous and acetous fermentation, and diſtillation, are compoſed of thoſe principles which, in common language, may be ſaid to belong peculiarly to wine; for, from ſome late experiments related by Dr. Crell*, it appears that they all contain phlogiſton, the acid of ſugar, and water; and that the peculiar character of each liquor is owing to the predominance only of the one or other of theſe principles; thus, in ardent ſpirit, the phlogiſton predominates; in vinegar the acid prevails; and in wine they are combined ſo equally, as, if I may uſe the expreſſion, to neutralize the liquor. This circumſtance, however, though it was right to notice it for ſake of accuracy, can, obviouſly, make no difference in the general principles of the preceding theory of fermentation†.

FROM

* See Scheele's Eſſays—page 386.

† SINCE I wrote the above I have read Mr. Henry's paper on Fermentation, &c. in the ſecond volume of the Manchester Memoirs, and I am much pleaſed to find my ſentiments

FROM the two natural proceſſes which have been related, the one ſynthetic, and the other analytic, the firſt approximating and uniting the principles of which ſugar is compoſed, in the acts of vegetation and animalization, and the other diſuniting them in

ments, on this ſubject, accord, ſo much as they do, with thoſe of ſo reſpectable a Chemiſt. Being each of us led by very different circumſtances to conſider the principles of fermentation, a ſimilarity of ſentiment may certainly be conſidered as reciprocally ſtrengthening both our opinions.

Mr. Henry conſiders the knowledge of the conſtituent parts of ſugar, as I have done, to be moſt likely to lead to a knowledge of the true principles on which this proceſs is effected, and to account for the ſeveral changes which are produced by it. He differs, however, in one reſpect from me, in ſuppoſing the decompoſition of water to take place during the act of fermentation, whereas I have conſidered the water merely as a menſtruum in which the principles of ſugar are diffuſed, upon being ſeparated from each other in the fermentatory operation. And I cannot help ſtill adhering to the ſame opinion, and for the following reaſons, 1ſt. becauſe the phlogiſton obtained from the ſugar ſeems ſufficient to account for that which exiſts in wine: 2d. becauſe I think it improbable that the water

in the act of fermentation, there is certainly the utmoſt reaſon to believe that theſe conſtituent parts of ſugar are really phlogiſton and a peculiar acid, agreeably to the firſt-mentioned experiment of the dephlogiſtication of ſugar by the nitrous acid.

THE experimentum crucis is, however, ſtill wanted, fully to eſtabliſh this theory, namely, the artificial ſyntheſis of ſugar, or its revivification by the application of phlogiſton to its acid, on the ſame principle as metals are revived from

ſhould be decompoſed under ſo low a temperature as that in which fermentation takes place: 3dly. becauſe if it did take place, at leaſt to any conſiderable extent, it is evident that a great part of the water would be diſſipated in the phlogiſton and dephlogiſticated air which would be liberated by its decompoſition; and laſtly, becauſe I have even my doubts reſpecting the converſion of water into air under any circumſtances; at leaſt the experiments which have been hitherto made, do not appear to me to be ſufficient to admit it as an eſtabliſhed chemical fact. See Dr. Prieſtley's Experiments on this ſubject in his ſixth volume of Experiments on Air, &c. and the Experiments of M. De la Metherie, in the Journal de Phyſique.

their

their calces by the ſame means, or as ſulphur is produced by the union of phlogiſton with the vitriolic acid, the conſideration of which will be the ſubject of the next ſection.

SECTION

SECTION IV.

On the Revivification of Sugar.

HOWEVER probable it may appear, from a conſideration of the preceding facts and obſervations, that ſugar would be produced by bringing the ſaccharine acid into circumſtances in which it could abſorb and ſaturate itſelf with phlogiſton, yet I fear there would be great difficulty in effecting this union by any common chemical operation; at leaſt there appears to be an inſuperable obſtacle to it, in the way in which this proceſs is uſually carried on in the inſtance of metals; for the degree of heat which is requiſite to diſengage phlogiſton from common inflammable ſubſtances, would, even ſuppoſing the phlogiſton to be attracted by the acid, be ſufficient to decompoſe and diſſipate the principles of the new formed ſugar by

by combuſtion: this circumſtance being in metals of no conſequence, as a greater and longer continued heat is requiſite to calcine metals, than to burn vegetable or animal matter.

WERE the attempt made, it is obvious that it ſhould be with thoſe bodies to which phlogiſton is moſt looſely attached, and which would, probably, part with this principle under a lower degree of heat than that which would produce the combuſtion of ſugar, as phoſphorus, ardent ſpirit, ſulphur, the electric ſpark, inflammable air, &c. and poſſibly, if it be admitted that the rays of the ſun contain phlogiſton, the acid might abſorb ſome of this principle, if expoſed a long time to its rays ſtrongly condenſed by a lens: indeed this will appear the leſs improbable, if we advert to the phlogiſtication of another acid, which is unqueſtionably effected by the ſolar rays, namely, the nitrous, which Scheele has found by repeated

peated experiments to acquire a yellow colour, and to emit yellow fumes by mere expoſure to the ſun's light; and it need not be obſerved. that the yellow colour of nitrous acid is acknowledged by chemiſts to be characteriſtic of its having imbibed phlogiſton.—Dr. Prieſtley has alſo found that a metallic calx may be reſtored to a metal, not only by being expoſed to the flame of inflammable air, but by the rays of the ſun being thrown upon it by a lens, when ſurrounded by inflammable air confined in a cloſe veſſel.

NOTWITHSTANDING, however, the ſeeming difficulty of reſtoring phlogiſton to the acid of ſugar, and thereby reproducing its ſaccharine ſtate, there are ſome common proceſſes which ſeem, in ſome degree, to effect it.

ACETATED lead, which is uſually called ſugar of lead, and obviouſly ſo from its ſweet taſte, may, I think, be conſidered

dered as a true ſugar produced by the phlogiſtication of the vegetable acid. This ſubſtance is the chryſtallized ſolution of white lead in vinegar. The ceruſe being an imperfect calx of lead, muſt contain ſome phlogiſton, though, evidently, not enough to make it aſſume the metallic character. The ſalt thus produced ſeems then to be compoſed of the calx of lead, of phlogiſton, and of the acid of ſugar contained in the vinegar. By the union of the two latter, ſugar is produced upon the general principles already advanced; and though, in this inſtance, it is ſo much impregnated with lead that it would be unfit for any of the purpoſes, for which ſugar is uſed, yet its ſweet taſte and another property which it poſſeſſes, ſufficiently evince its truly ſaccharine ſtate; for it is well known to Chemiſts, though it has hitherto been very difficult to explain, that by diſtillation an inflammable ſpirit may be obtained from ſugar of lead, and though, from the adventitious circumſtance of a

metallic combination, it may differ, in ſome of its principles, from ardent ſpirit obtained from pure ſugar, by the double operations of fermentation and diſtillation, yet agreeing with it in the chief characteriſtic of that fluid, inflammability, there can be little doubt of its being in itſelf ſimilar, as well as derived from a ſimilar ſource, more eſpecially as it is well known that inflammable ſpirit cannot be obtained from a ſolution of lead in the vitriolic acid, or any other than the vegetable*.

The revivification of perfectly metallic lead from the ſugar of lead by heat alone, which is a well eſtabliſhed chemical fact, is another proof that the compound contains phlogiſton, and conſequently ſtill more ſtrongly favours the preceding conjecture, that the ſugar is produced by its union with the vegetable acid of the vinegar.

* Neumann's Chemiſtry—vol. i, page 86.

It may indeed, at firſt, appear paradoxical that the ſalt of lead, obtained from a ſolution of calx of lead, which obviouſly could not contain, in its calciform ſtate, a ſufficient quantity of phlogiſton to put on the metallic character, ſhould be capable of producing true lead by heat alone; yet, if it be conſidered that the pureſt vinegar contains phlogiſton, it may reaſonably be ſuppoſed that the deficiency of phlogiſton is ſupplied from thence. For though the vinegar be evidently combined with too ſmall a quantity of phlogiſton for it to aſſume the ſaccharine character, and the ceruſe be combined with too ſmall a quantity of phlogiſton to aſſume the metallic character, yet when they are both united, the ſum of phlogiſton in the whole, appears to be ſufficient in one proceſs, by a union with the acid, to produce a ſugar, and in the other, by a union with the metallic calx, to produce a metal; and the different modes in which the two operations are conducted, may, perhaps, ex-

plain, why in the firſt the reſult ſhould be the ſugar, and in the latter the metal.

In the firſt, which is merely a ſolution of the ceruſe in vinegar by digeſtion, a very gentle heat is applied, much below that which is ever made uſe of in revivifying metals from their calces, and therefore it may be preſumed not ſufficient to effect the union of the phlogiſton and the calx in this inſtance, it not being even ſufficient to diſſipate the acid by evaporation. At the ſame time, as a moderate heat will enable vinegar to ſeparate phlogiſton from lead, as may be inſtanced in the production of ceruſe, in which the heat applied is only that of a dunghill, it is probable that the heat made uſe of in this operation is ſufficient to diſengage the remaining phlogiſton from the ceruſe, and its union with the acid, with which it has a ſtronger affinity, follows.

In the ſecond operation, the degree of heat applied is preciſely the ſame as in that of ſmelting; the acid is therefore immediately ſeparated and diſſipated, and the calx and phlogiſton uniting, the reviviſication of the metal is effected in the ſame manner as when a metallic calx is in contact with any other phlogiſtic body undergoing combuſtion.

Should the foregoing conjecture, reſpecting the ſweetneſs of acetated lead, be admitted, it follows, that the effect of lead, in ſweetening ſour wines, does not depend upon this ſubſtance as a metallic but ſimply as a phlogiſtic body; and ſhould further experiments prove this, ſome proceſſes may, probably, be adopted, by means of which an equal portion of phlogiſton may be imparted to the liquor uncombined with ſo noxious a metal.

This, evidently, throws a new light upon the ſubject of recovering ſour wines,

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and a conviction of this, among manufacturers and venders of wine, with the knowledge of some other equally cheap and easy method of imparting phlogiston to sour wine, would go further to prevent the use of lead, in sweetening wine, than the most severe prohibitory edicts. And this, important as it undoubtedly is, certainly cannot be very improbable, because even now there is a process used by makers of wine which is truly phlogistic, and is that which I proposed to mention as another instance of the revivification of sugar from its acid.

It is a common practice with manufacturers of wine, to burn common matches, or rags impregnated with sulphur, over the surface of wine which has discovered any marks of sourness, and if continued for some time, it never fails to diminish the acidity of the liquor. In making cyder, in which liquor the acid is usually too abundant, the effect of this mode of phlogistication,

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in ſweetening it, is ſo certain and conſiderable, as to make it almoſt univerſally a part of the common proceſs of cyder-making, at leaſt in thoſe parts of the kingdom, where apples do not obtain perfect maturity.

FRONTIGNAC wine, which is very ſweet, is frequently imitated by dealers in wine, and I am told that this is principally done by impregnating ſome of the weak and acidulous wines very powerfully with ſulphur; and, indeed, the ſulphureous impregnation of this wine may often be detected by the taſte and ſmell.—Theſe kinds of factitious wines are chiefly manufactured in Holland, and I have been informed by an intelligent traveller, that large quantities of weak and ſour wine are annually exported from Nantz and ſold to the Dutch, where they are, probably, changed into ſweet wine by the forementioned or ſome ſimilar proceſs.

NOR

Nor is this merely a modern practice, for the uſe of phlogiſtic fumes, in leſſening the acidity of vinous liquors, and of the total excluſion of air in preventing a further diſpoſition to fourneſs, was well known to the ancients; for, whenever ſigns of this began to appear, the wine was immediately poured off into freſh caſks, impregnated with the *vapor of ſulphur*, they were removed into a cooler ſituation, and the new caſks were ſo conſtructed as totally to prevent the acceſs of the external air*.

The influence of the vapor of ſulphur thus applied, has, however, been very differently explained by chemical writers, as they have ſuppoſed that it ſerves no other purpoſe than ſimply to check the fermentation, by preventing the further eſcape of thoſe principles, which, during

* Barry on the Wines of the Ancients—pages 8, 46 and 47.

the

the proceſs, are attracted by the air, in the ſame manner as the reſpiration of animals, and the combuſtion of inflammable ſubſtances, are inſtantly ſtopped by their being reſpectively ſurrounded with an atmoſphere which is ſaturated with phlogiſton.

THAT this muſt be one effect of a ſtratum of phlogiſtic vapor covering the ſurface of a vinous liquor when fermenting, is very certain; but it is at the ſame time as certain, that the mere excluſion of the external air, and the removal of the liquor into a cooler ſituation, would equally put a ſtop to the operation, and as this would be a more ſimple and much leſs troubleſome method of effecting this purpoſe than the application of the ſulphureous fumes, it is not probable that the latter mode would be preferred to the former, unleſs ſome other effect were produced on the wine, more than the ſuppreſſion of the fermentation; and ſurely if the preceding general principles be admitted,

that effect on the wine which has been ſuggeſted, is the moſt likely to take place under ſuch circumſtances.

ANOTHER inſtance, in which it appears to me very probable, that the revivification of ſugar from its acid is effected by its union with phlogiſton, is in the calcination of cream of tartar: for during this operation it never fails to emit a ſmell perfectly reſembling that of burnt ſugar; and when it is acted upon by ſome other chemical operations, a reſiduum is produced which much reſembles treacle in color, odor and conſiſtence. Dr. Prieſtley has particularly noticed this fact in the relation of the experiments he made with calcined tartar, in order to diſcover the kind of air it gave out*.

THERE can be no difficulty in accounting for this ſeeming production of

* Vol. iv. pages 109, 402 and 403.

ſugar,

ſugar, in the calcination of tartar, on the foregoing principles; for as, according to the common chemical analyſis of tartar, it ſeems to conſiſt of an acid, the vegetable alkali, an oil and an earth, it is evident that during its combuſtion, phlogiſton may be ſet at liberty from the oil, and of courſe may form an union with the acid, which has before been aſcertained to be ſimilar to the acid of ſugar. But the ſugar thus produced being deſtructible by fire, it is obvious that none of it can remain when the calcination of the tartar is compleat, the only fixed parts which are left, being the alkali, and the earth. The time, therefore, at which we might moſt expect to diſcover it, will be, when the combuſtion of the tartar is only partial; for when ſome phlogiſton has eſcaped from that part which is burnt, and ſome acid remains in that which is not burnt, it may be ſuppoſed that an union between theſe principles may be effected, and that by it a new compound of ſugar may be pro-

duced. Experiment very well accords with this, for when the tartar is but little calcined, the ſaccharine ſmell is very ſtriking, the whole ſubſtance is moiſt and of a reddiſh brown colour; but when more calcined it becomes perfectly dry, is of a deep black, and has no ſmell. When mixed with water, in the firſt ſtage of calcination, it communicates a tinge, which the water retains after filtration; but when more completely calcined, the black matter of the calx being incapable of ſolution, if put into water, it ſoon precipitates, leaving the liquor a colorleſs ſolution of the alkali: If nitrous acid be added to this and the whole be evaporated, common nitre is formed; but if nitrous acid be added to the colored ſolution of the imperfectly calcined tartar, not only are chryſtals of nitre formed, but another brown ſaline depoſit is produced, which very much reſembles ſugar; though it appears too moiſt to chryſtallize into grains, and

too

too acid to reſemble ſugar in taſte, both which circumſtances may, poſſibly, be owing to the ſame ſuperabundance of acid, which is ever obſerved in native ſugar, before the admixture of lime; for it may be remarked, that ſugar, as a natural product, ſeems to be ſuperſaturated with acid, in the ſame manner as tartar, which, though a ſaline compound of an acid and an alkali, is, in its natural ſtate, as firſt depoſited, ſuperſaturated with the acid.

It may, perhaps, be urged, that the mere ſmell of ſugar is, in the preceding proceſs, too imperfect a teſt of its preſence. This odor is, however, ſo peculiarly characteriſtic of ſugar, that I doubt not but thoſe who will make the experiment will readily allow its ſimilarity; and I think it may be as readily admitted to be, in this inſtance of the calcination of tartar, derived from ſugar, as the ſulphureous ſmell which ariſes in the burning of common gypſum, is admitted

to

to be derived from ſulphur. In the latter caſe the ſulphur is ſaid to be produced by the union of the vitriolic acid of the ſelenite, with the phlogiſton contained in ſome of the animal or vegetable ſubſtance, which is uſually combined with gypſum, as found in the earth*: and it is, ſurely, equally as reaſonable to ſuppoſe, that in the former caſe ſugar ſhould be produced by the union of the ſaccharine acid and phlogiſton, it being no more difficult to prove the previous exiſtence of both theſe in tartar, than it is to prove the previous exiſtence of the vitriolic acid and phlogiſton in gypſum.

It has already been obſerved that, in the malting of barley, it is probable ſugar is produced by the evolution of phlogiſton and the requiſite acid, which takes place during the vegetation of the grain, and both which previouſly exiſted in a con-

* See Fourcroy's Chemiſtry.—Article Gypſum.

cealed

cealed ſtate in barley. I am, however, inclined to think that the ſaccharization of all the acid which is evolved by this proceſs, cannot be effected without the application of more phlogiſton than ſeems to be produced from the grain, during its vegetation*, and that this is, probably, effected in the ſubſequent part of the proceſs of malting; in which it will appear, that the grain is a long time expoſed to phlogiſtic fumes; and which, therefore, may, perhaps, be conſidered as another inſtance of the revivification of ſugar from the acid by the union of phlogiſton.

It has, indeed, been commonly underſtood, that the malt, when ſufficiently

* And agreeably to this conjecture, it may be remarked, that when the malt lies upon the floor, and even when the germination has proceeded as far as is thought proper, a ſour ſmell may uſually be perceived. Indeed my obſerving this circumſtance in a late viſit to a malting office, firſt led me to ſuppoſe that the ſaccharization was not completed in the vegetative part of the proceſs, and that a further phlogiſtication was, therefore, neceſſary.

ſprouted

ſprouted by the firſt part of the operation, is laid upon the kiln, merely that it may be quickly and perfectly dried, and that the germination may be thereby effectually ſtopped; but if the mode, in which this is accompliſhed, be duly conſidered, it will be found that ſomething more than heat is applied; and it is, moreover, a fact, aſcertained by repeated experiments, that drying the grain, in any other way, as reſpecting the application of heat, than in that which is commonly made uſe of, though it may equally deprive it of moiſture, will not produce perfect malt.

The operation of kiln drying the malt, as it is called, is as follows; the grain is ſpread thick upon a floor made of flat bricks, or iron plates, which are full of perforations; immediately under this floor is the oven or furnace, in which is a large fire made of coaks, cinders, or in ſome places, billet wood; a current of air, at the mouth of the furnace, keeps up the combuſtion

buſtion of the coaks, and the air which is phlogiſticated by their burning, and which, in a common fire-place, riſes up the chimney, paſſes, in this inſtance, through the apertures in the floor, and penetrates the whole ſtratum of malt, before it can paſs into the external air. Under theſe circumſtances, it is evident, that the interſtices of the malt muſt be filled with phlogiſtic air, and as the grain uſually remains in this ſituation about two days, it is obvious, that if it have the power of abſorbing phlogiſton, it certainly muſt do it, when ſo long in contact with it. And that the malt does really imbibe ſome of this principle, is not only probable on the general ground of the truth of the preceding theory, but, I believe, it will be found, that the phlogiſticated air which riſes from the burning ſubſtances underneath, is corrected in paſſing through the malt: for without its being meliorated by this or ſome other cauſe, it is evident that the air in the kiln-chamber, more eſpe-

cially the lower ſtrata of it, muſt be noxious, and, probably, even ſo much ſo as to be unfit for reſpiration and combuſtion. But ſo far from this being the caſe, I am informed that workmen will frequently lie and ſleep many hours on the malt in this ſituation, without ſuffering any inconvenience: And after mentioning this, it is ſcarcely neceſſary to add, that I find alſo, by experiment, that a candle will burn perfectly well in the air which is immediately on the ſurface of the malt.

WERE heat alone ſufficient for the purpoſe of compleating the operation of malting, it certainly might be applied in a much more cheap way than is at preſent done; for the floor on which the grain is laid might, unqueſtionably, be heated equally without there being perforations in it, as with them; in which caſe one kind of fuel would be as good as another, and, conſequently, the preſent expence of previouſly burning the coals

to

to convert them into coaks or cinders might be ſaved.

But, admitting, that the application of phlogiſton to the malt, as well as heat, is requiſite in this operation, the neceſſity of theſe perforations becomes evident, and, alſo, the propriety of previouſly burning the coals in ſuch a way that all the water and thoſe other heterogeneous particles which compoſe ſmoke and ſoot may be diſſipated; for theſe, merely as ſuch, would, obviouſly, contribute little to the phlogiſtication of the malt, and would, evidently, impart ſome offenſive flavor, if not ſome noxious quality to it*.

SECTION

* Reasoning from the above premiſes, it would ſeem that as all the farinaceous part of the barley is ſeldom diſſolved in brewing, and the grains which are left have uſually the diſpoſition to become ſour, thereby manifeſting ſome of the acid principle to be ſtill exiſting in them, it is not improbable, but ſome further ſaccharine matter might be obtained from the grain, by another expoſure to phlogiſticated air, or, in other words, by being once more laid on the kiln; I have much wiſhed to make this experiment,

SECTION V.

Concluſion.

IN recapitulating the ſeveral facts and obſervations which have occurred in the preceding enquiry, under the reſpective heads of the natural production of ſugar, the ſeparation of its component parts by fermentation and ſome other operations, and its revivification or reduction by the artificial reunion of thoſe parts, however imperfect the chemical reader may conſider ſome of the examples, which have been adduced, and however defective the experimental part muſt be acknowledged to

ment, but having no opportunity at preſent of doing it in a way that would, in my opinion, be ſufficiently deciſive, I muſt be ſatisfied with merely mentioning my conjecture, truſting that I may one time or other have an opportunity of fully aſcertaining it by experiment, or that ſome other perſon profiting by the above hint, may make the trial, and perhaps in a way more likely to anſwer the purpoſe than any I could ſuggeſt.

to be, yet, as they all, as far as they go, very uniformly and ſtrikingly agree in proving the ſame general principles, and as, moreover, there are no facts which have occurred in the courſe of the enquiry, which contradict the above general theory, I think we may ſurely be permitted to adopt it, and to conſider ſugar, therefore, as another of the ſulphurs.

At the ſame time, it is much to be wiſhed, that the practical chemiſt would proſecute experiments on this ſubſtance, and particularly on the acid of ſugar, endeavouring to compleat thoſe which have already been made by Scheele and Bergman, and which ſeem to be principally defective, in their not having, among the various combinations they made with this acid and earth, alkalis, other acids, and metals, united it with phlogiſton.

It may, indeed, be ſaid, that this has, in ſome meaſure, been done by Bergman, in the

combination of the acid of ſugar with the metals, which are phlogiſtic bodies; but if this be admitted, the accounts he has given of the reſults, afford no information reſpecting the effects of the metals in ſaccharizing the acid, if I may ſo expreſs myſelf. In its combination with iron, however, this circumſtance is caſually mentioned, and it ſeems, as far as it goes, to favour this hypotheſis; for he ſays, "the acid of ſugar attracts iron with efferveſcence, which is occaſioned by the extrication of its *phlogiſton*; the ſolution has an aſtringent *ſweetneſs**."

I CANNOT, indeed, help urging a further experimental proſecution of this ſubject, to thoſe who have more opportunities and are better able to make chemical experiments than myſelf, and not merely with a view to the extenſion of chemical facts, or the proving a philoſophi-

* Bergman's Eſſays, vol. page i. 323.

cal

cal theory, but as it may poſſibly be applied to the improvement of ſome important art or manufacture; for, in conſequence of further chemical attainments, and which the united and well-directed labors of ſo many ingenious men, at this time, lead us, not unreaſonably, to expect, ſhould we become better acquainted with that extraordinary principle, phlogiſton, and be more able to detect its preſence and to transfer it from one body to another, it would be hazarding very little to predict that the proceſſes of wine-making, brewing, &c. and of all others in which either the ſeparation or combination of phlogiſton is effected, would be much benefited by ſuch a circumſtance. Perhaps, even ſugar itſelf might become a ſubject of manufacture, and by the requiſite application of phlogiſton, it might be obtained from many vegetables, which in their natural ſtate, contain only the acid principle of that ſubſtance.

WERE there, indeed, no other reaſon to encourage a further inveſtigation of this ſubject, that which was ſuggeſted in conſidering the nature of wine, would, ſurely, be ſufficient, as it ſeems from thence not unreaſonable to expect that it may lead to the diſcovery of ſome method of ſweetening ſour wine by the application of phlogiſton, unattended with any of the pernicious effects of ſaturnine ſolutions, which notwithſtanding the preſent laws in force againſt their uſe, in all countries where wine is drank, will probably continue to be mixed with it, by makers and venders of wine, whilſt they have no other method of reſtoring an unſaleable article.

THE importance of ſuch a circumſtance to ſociety need not be inſiſted upon, more eſpecially to the medical reader, who cannot be ignorant of the very dreadful diſeaſes which are produced by the admiſſion of this metal into the ſtomach and inteſtines, and of the very extenſive miſchief,

miſchief which has already been occaſioned by its introduction into the conſtitution, through the medium of wine, cyder, &c.

The very claſſical and elaborate enquiry of Sir George Baker into the cauſe of the Cholica Pictonum, and his other excellent obſervations on the Poiſon of Lead, in the London Medical Tranſactions, will fully juſtify the preceding remark, and afford the moſt ample information on this head.

It would be ſuperfluous to enumerate the various experiments which would be neceſſary in further purſuing this ſubject, as they muſt obviouſly occur to every chemiſt, who conſiders it with attention. I am aware, however, that there are many difficulties which would probably ariſe, and more eſpecially to thoſe who, like myſelf, have not had much experience in chemical proceſſes; and there is one circumſtance which appears likely to be, at preſent at leaſt, a ſource of no ſmall uncertainty in aſcertain-

ing with accuracy the results of many of these operations; and this is the want of a proper test of the presence of sugar.

In the simple and uncombined state of sugar, the taste would be sufficient for this purpose, as sweetness, properly speaking, belongs alone to saccharine matter: but when it is either very much diluted in any liquid, or when its peculiar taste is covered by the predominant taste of some other substance, with which it may be united, this can, evidently, be no longer relied upon to discover its presence.

Nor is it difficult merely to discover the presence of sugar when much involved in other matter; it is also very difficult to ascertain the quantity of sugar which may be dissolved in any simple menstruum, in which the presence of sugar may be sufficiently obvious to the taste. A want of a method of effecting this has long been complained of by brewers, makers of wine, cyder, &c.

and

and it has lately ſo much engaged the attention of thoſe who are intereſted in this ſubject, that it is, this year, the ſubject of one of the premiums offered by the Society for the Encouragement of Arts, Manufactures, and Commerce, in London, a ſilver medal being propoſed as an honorary reward "for diſcovering a practicable method of aſcertaining the degree of ſweetneſs in ſaccharine ſubſtances."

ATTEMPTS have, indeed, been lately made to aſcertain the quantity of ſugar contained in malt worts; at leaſt this would ſeem to be the caſe, from the name which has been given to the inſtruments which are employed for this purpoſe, namely, *ſaccharometers**. But however uſeful thoſe inſtruments may be in pointing out the addition of matter which the liquor, in which

* THE application of an inſtrument of this kind is fully explained in a work of conſiderable ingenuity, on the ſubject of brewing, lately publiſhed by Mr. J. Richardſon, of Hull.

malt has been infuſed, may have acquired, yet as they effect this merely by ſhewing the increaſed denſity of the fluid, and do not, on any chemical principle, diſcover of what nature the adventitious matter is which is diffuſed in the water, and to which it owes its increaſe of denſity, and which, even in the inſtance recited, may be in part farinaceous as well as ſaccharine, it is evident that they muſt be inadequate to the detection of ſugar merely as ſuch, and, conſequently, are not likely to obviate the difficulty which has been ſuggeſted.

Could the proceſs of fermentation be eaſily induced on ſubſtances which may be ſuſpected to contain ſugar, notwithſtanding their being involved in other matter, the reſult being a vinous liquor, would be an unequivocal proof, that ſugar had previouſly exiſted in them: but, (not to mention the very great improbability of effecting this on ſugar under ſuch circumſtances, and more eſpecially on ſuch ſmall

ſpecimens

ſpecimens of ſuch ſubſtances as might, perhaps, be the ſubject of inveſtigation) if it even were effected, it could ſcarcely be conſidered as a teſt of the preſence of ſugar, as this proof could not be exhibited until, by a decompoſition of the ſugar, it might properly be conſidered as no longer exiſting in the ſubſtance.

When ſugar is ſimply combined with vegetable mucilage, or with any other ſubſtance which is inſoluble in ſpirit, it certainly may be ſeparated by digeſting the compound in that fluid, and afterwards evaporating the ſpirit, in the way in which Magraaf obtained ſugar from ſuch a variety of vegetables, and in which way I have been informed, by a gentleman lately returned from the Continent, that ſome attempts are proſecuting, at this time, in France, with the proſpect of obtaining ſugar from many different vegetables which are cultivated in that country, and in ſuch quantities as may make it become an object of mercantile advantage.

But

But even this will ſcarcely obviate the difficulty ſuggeſted, being rather calculated to ſeparate ſugar from ſuch ſubſtances which exhibit ſome marks of its preſence by their ſweet taſte, and which ſeparation they, obviouſly, cannot effect, if the adventitious matter, with which it is united, be alſo ſoluble in ſpirit of wine.

The application of the nitrous acid to ſubſtances which may be ſuppoſed to contain ſugar, may, perhaps, be thought to be another means of detecting it; but this, like the proceſs of fermentation, as it decompoſes the ſugar, and diſſipates the phlogiſtic part of it, could, at moſt, only render it probable that ſome ſugar had been contained in them; and as the ſaccharine acid would be the only principle remaining, this proceſs muſt be rather conſidered as diſcovering that than ſugar.

Combustion, for the ſame reaſon, would ſeem, likewiſe, to be unequal to the detection of ſugar under theſe circumſtances,

ſtances, more eſpecially as all its component parts are diſſipated by the application of much heat. There is, however, one circumſtance attending this operation, which, I think, may be conſidered as affording a tolerable criterion of its preſence; and this is the characteriſtic odor emitted by ſugar during burning.

It was this circumſtance which led me, as before obſerved, to ſuppoſe that the principles of ſugar exiſted in tartar; and as its preſence was evidently betrayed by the peculiar ſaccharine ſmell emitted during its combuſtion, it may, probably, in ſome other inſtances, where it is ſo much covered by adventitious matter as to be concealed from the ſenſe of taſte, be rendered obvious to another ſenſe by the operation of burning.

Imperfect as this teſt of the preſence of ſugar undoubtedly is, it appears to be the moſt likely, of any which have been mentioned

tioned, to aſſiſt us in diſcovering it when much involved in foreign matter.

It will, however, probably, be the buſineſs of future experimenters to enquire whether ſugar has any peculiar affinities; and ſhould theſe be known, they will obviouſly lead to more accurate methods of detecting its preſence, and aſcertaining its quantity under its different combinations, as alſo to the improvement of the ſeveral proceſſes of ſeparating it from different ſubſtances, and of refining it for uſe.

FINIS.

ERRATA.

Page 9 line 17 for *as*, read *with*.
— 39 — 17 for *ſufficiently*, read *in ſome degree*.
— 50 — 17 for *explained*, read *underſtood*.
— 51 — 6 dele *that*.
— 63 — 8 for *this*, read *theſe*.
— 66 — 15 after *being*, inſert a *comma*.
— 67 — 7 after *muſt*, inſert *be*.

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